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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : G01G 19/42, 23/16	A1	(11) International Publication Number: WO 90/01683 (43) International Publication Date: 22 February 1990 (22.02.90)

(21) International Application Number: PCT/GB89/00912

(22) International Filing Date: 9 August 1989 (09.08.89)

(30) Priority data:
8818951.9 10 August 1988 (10.08.88) GB

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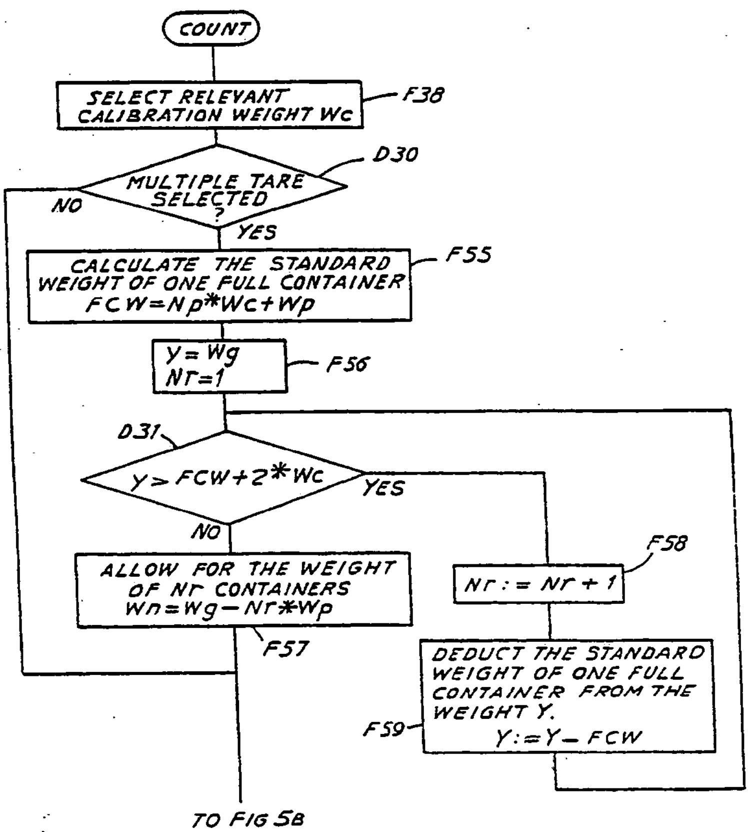
(81) Designated States: DE, GB, JP, US.

Published
With international search report.

(54) Title: METHOD AND APPARATUS FOR DETERMINING THE NUMBER AND/OR VALUE OF WEIGHED PACKAGED ITEMS

(57) Abstract

Weighing apparatus for weighing currency notes or coins has a weighing platform (4) coupled to a load cell (14) for generating a weight signal dependent upon the weight of items on the platform. The weighing machine includes a microprocessor (26) with associated memory (32, 34) which determines the number and/or value of the weighed items by dividing the weight signal by an appropriate weight factor. When a number of standard packages of items are placed on the weighing platform (4), the apparatus automatically calculates an appropriate tare allowance to deduct from said weight signal to form a nett weight signal from which the number and/or value of the weighed items is determined. The tare allowance is calculated by dividing the weight signal by a preset value, for example, representative of the weight of a single package, and then multiplying the quotient formed by a preset tare value representative of the weight of the packaging.



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METHOD AND APPARATUS FOR DETERMINING THE NUMBER AND/OR VALUE OF WEIGHED PACKAGED ITEMS

The present invention relates to a method and apparatus for determining the number and/or value of weighed packaged items.

Many items are stored or sold in pre-wrapped packages. Currency is often pre-wrapped in this way, for example, notes are grouped together and held by a band or clip, and coins are wrapped in a roll or bagged. Small hardware items, such as screws and hooks are also generally sold in packages.

There is frequently a need to ascertain the number of individual items within a package, and in the case of currency to determine the value of the items in that package.

Counting machines for determining the number and/or value of items such as coins or bank notes by weighing are known. For example, European Patent No. 0040539 describes such a machine which determines the number and/or value of the weighed items by dividing a total weight signal by an appropriate weight factor.

However, before an accurate determination of the number and/or value of the items in a package can be made, the weight of the packaging needs to be taken into account. This is done by determining the weight of the packaging, recording this weight, "the tare weight", and then subtracting the predetermined tare weight from the total weight signal to form a nett signal representative of the weight of the items without the packaging. It is this nett signal which is then divided by the weight factor to determine the number or value of the items.

The present machines with a tare facility can only determine the number and/or value of packaged items where single packages are individually weighed, or

where the packages are stacked successively and the total packaging weight does not exceed more than 0.5 of the weight of an item. However, such packages are often presented in bundles and it would be useful to be able to weigh the packages in their bundles.

According to a first aspect of the present invention there is provided apparatus for determining the number and/or value of items packaged in one or more packages, said apparatus comprising processor means arranged to receive a weight signal representative of the total weight of the packages, said processor means having means for calculating from said weight signal a tare allowance representative of the weight of the packaging of said packages, and means for subtracting the calculated tare allowance from said weight signal to form a nett weight signal representative of the weight of the items.

Apparatus of the invention is enabled to calculate a tare allowance from the weight signal. Thus a user can place a number of packages onto the apparatus which subtracts an appropriate tare allowance from the weight signal before evaluating the actual number of items.

In an embodiment, said means for calculating said tare allowance comprises means for dividing said weight signal by an appropriate preset value to form a quotient, and means for multiplying a preset tare value representative of the weight of the packaging by said quotient to form said tare allowance. For example, said quotient may be formed by repeatedly subtracting said preset value from said weight signal, and incrementing a counter for each said subtraction, until said weight signal is smaller than said preset value, and the contents of the counter then providing said quotient.

The preset value by which said weight signal is

divided may be representative of the weight of the items in a single package or of the total weight of one package such that said quotient is at least approximately representative of the number of packages. The preset tare value is then representative of the weight of the packaging of a single package.

The quotient formed may not be a complete integer. In these circumstances it may be utilised directly to form said tare allowance, or an appropriate exact integer therefor may be formed. This exact integer would then be utilised to form said tare allowance.

In an embodiment, said processor means further comprises means for dividing said nett weight signal by an appropriate weight factor to determine the number and/or value of said items. For example, said weight factor may be representative of the weight of the items in a single package, or said weight factor may be a calibrated value representative of the weight of a single item.

The present invention also extends to a weighing apparatus for determining the number and/or value of weighed items, said apparatus comprising means for producing a weight signal, and apparatus as defined above for determining the number and/or value of packaged items and arranged to receive said weight signal, wherein means are provided for determining the number and/or value of the weighed items from said nett weight signal.

Preferably, said means for determining the number and/or value of the weighed items comprises means for dividing said nett weight signal by an appropriate weight factor.

Preferably, said means for producing the weight signal comprises weighing means for producing an actual measured weight.

In an embodiment arranged to weigh items of

different denominations, each denomination representing a different value, said weighing apparatus comprises storage means in which a list of denominations is stored together with the value assigned to each denomination, and a respective weight factor for each denomination in said list, wherein each said weight factor is representative of the weight of a respective predetermined number of the items of that denomination.

Preferably, said processor means has means for dividing said nett weight signal by a selected weight factor to form a quotient representative of the number of items being weighed, and means for comparing said quotient with tolerance limits, and output means for signalling that said quotient is within said tolerance limits and so acceptable or that said quotient is outside said tolerance limits and so unacceptable. In this case, said processor means is arranged to be responsive to said output means signalling that said quotient is acceptable to enable multiplying means to multiply at least part of said quotient by the value assigned to said denomination whereby the value of the weighed items is determined. When said quotient is acceptable an appropriate exact integer value therefor is formed, and it is said exact integer value which is multiplied by said multiplying means with said assigned value.

Preferably, the apparatus is for counting coins or notes and each weight factor corresponds to the weight of a respective number of coins or notes of a respective denomination.

According to a further aspect of the present invention there is provided a method of determining the number and/or value of items packaged in one or more packages, the method comprising the steps of calculating a tare allowance from a weight signal

representative of the total weight of the packages, and subtracting the calculated tare allowance from said weight signal to form a nett weight signal representative of the weight of the items.

Preferably, said weight signal is divided by a preset value representative of the weight of said items to form a quotient, and a preset tare value representative of the weight of the packaging is multiplied by said quotient to form said tare allowance.

Embodiments of the present invention will hereinafter be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows a perspective view of weighing apparatus of the invention,

Figure 2 shows a block circuit diagram of the apparatus of Figure 1,

Figure 3 shows a flow diagram of the main weighing routine performed by a processing unit of the weighing apparatus,

Figure 4 shows a flow diagram of a verifying routine of the weighing apparatus,

Figures 5A, 5B and 5C show a count routine of the weighing apparatus, and

Figures 6A, 6B and 6C together show a flow diagram of a key handling routine of the weighing apparatus.

The drawings illustrate a weighing apparatus for determining the number and/or value of weighed items. The weighing apparatus described and illustrated herein is generally similar to that described and illustrated in our International Application No. PCT/GB88/00391 (WO 88/09485) but is modified, as will become apparent, to have a tare facility designed to make it unnecessary to weigh packaged items in single packages. The weighing

apparatus, as is apparent from Figure 1, is a stand alone weighing machine having a housing generally referenced 2 in which an electronic circuit including processing means and electronic storage is contained. A block diagram of the circuit of the machine is illustrated in Figure 2.

As shown in Figure 1 a weighing platform 4 for receiving items such as coins or notes whose number and/or value is to be determined is associated in known manner with an electronic precision weighing device for the provision of electrical output signals which are proportional to the weight applied to the weighing platform 4. A number of input keys 5 to 11 are provided in a panel of the housing 2 for inputting information to the processing unit. Furthermore, a display panel 12 for displaying appropriate messages under the control of the processing unit is also provided in a panel of the housing 2. Naturally, this display panel 12 may be constituted by appropriate display means.

Figure 2 shows a block circuit diagram of the electronic circuit of the machine received within the housing 2. The weighing platform 4 is associated with a load cell 14 of the electronic precision weighing device. This load cell 14 is supplied with a regulated power supply by way of a power supply regulator 16 connected across a battery 18. This load cell produces an electrical output signal whose magnitude depends upon the weight applied to the load cell by way of the weighing platform 4. This output signal is fed to an amplifier 20, and the amplified output signal is then applied to an analogue to digital converter 22. It will be seen that the analogue to digital converter 22 is also fed with a regulated power supply from the regulator 16. The power supply applied directly to the converter 22 acts as a reference so that the digital

output signal from the converter 22 is generally independent of any fluctuations in power supply levels and therefore is substantially proportional to the weight applied to the load cell 14. In known manner, the power supplied to the electronic precision weighing device is isolated from the power supplied to the processing means to avoid problems with noise.

A further power output 24 of the regulator 16 is connected in known manner to provide power to a processing unit 26 and units associated therewith.

In the embodiment shown, the processing unit is a micro-processor 26 whose associated keyboard 28 is constituted by the keys 5 to 11. A display 30 of the micro-processor 26 is constituted by the display panel 12 together with appropriate display drivers and interface means (not shown). In the embodiment illustrated, the micro-processor 26 is connected both to a pre-programmed memory 32 which may be a read only memory (ROM) or a programmable read only memory (PROM), and to a memory 34 which is a random access memory (RAM). The pre-programmed memory 32 includes the programs for the micro-processor 26 as well as data relating to the items which the weighing machine is arranged to weigh.

The machine is described below as a machine arranged for weighing bank notes and/or coins and/or tokens or other counters representative of monetary value. However, it should be noted that the machine can be used for the weighing or counting of items other than those having a monetary value. For simplicity, in the following description, we will consider the operation of the machine as a currency counter programmed to be responsive to the notes and coins of a single currency, although the machine may be programmed to weigh the notes and coins of more than one currency.

The information held in the memory 32 includes a list of the denominations of the notes and coins of the currency of interest. In addition, the memory 32 includes the monetary value of each denomination. There is also stored within the memory 32 weight limits below which the weighing platform is deemed to be empty, and weight limits below which the weighing platform is deemed to be empty and zero tracking will occur.

The memory 32 also contains the weight of each denomination of the coins and notes. In addition for each denomination of notes, the memory contains the following information: an Error Band Table providing predetermined error band limits for each note dependent upon the number of notes being counted; the maximum number of each note which may be counted in any single operation; and the largest number of notes which may be placed on the scale pan before a warning message is displayed.

This latter information is utilised in error reduction techniques described hereinbelow, which are also described in our copending application No. PCT/GB89/00630. It would be possible to store the same information in respect of the coins of the currency. Generally, however, the weight of coins is very stable and they can be counted and/or valued very accurately simply by weighing and without any calibration or error reduction techniques being necessary.

The memory 32 includes the monetary value of each denomination, and in addition stores:

1. The weight of a single item of each denomination.
2. The weight of the packaging of a single package of such items.
3. The number of items which would be wrapped in

a single package.

The use of all of the information pre-programmed into the memory 32 will become apparent from a consideration of the program routines illustrated by the flow diagrams of Figures 3 to 6 which are described below.

It will be appreciated that the information in the memory 32 is generally programmed in the factory. However, the programming of the memory 32 is not within the scope of this invention and will not therefore be further described.

When the machine of Figure 2 is switched on, the micro-processor 26 is programmed to initiate any initialisation routines. On first switch on, this involves the transfer of certain information from the memory 32 to the RAM 34. It will be seen that the RAM 34 is permanently supplied with standby power by way of the regulator 16 so that the RAM is not volatile. Generally, it is the information in the RAM 34 which is utilised by the micro-processor 26 in the performance of the programs. This enables the information stored in the RAM 34 to be updated as necessary. In addition, full calibration and partial recalibration programs, which are not described herein, may be provided to modify the information stored in the RAM 34.

When the machine of Figure 2 is on, the micro-processor 26 runs its main program continuously. This program is the weighing routine shown in Figure 3. In addition, the weighing device is arranged by way of micro-processor timing means to periodically supply a weight signal to the micro-processor 26. For example, a new weight reading can be supplied ten times a second.

The micro-processor 26 is also programmed to

continuously run a keyboard read routine causing the state of the keys 5 to 11 of the keyboard 28 to be read periodically. This information as to key states is stored in appropriate locations of the RAM 34. For example, in a preferred embodiment, the keyboard is read once every four milliseconds and the keyboard map showing which keys are currently pressed is stored in RAM 34. In known manner, the keyboard read routine is provided with anti-bounce checks.

The provision of a suitable keyboard read routine and of a timing means for periodically supplying weight signals will be within the competence of anyone skilled in the art and so are not further described herein.

Figure 3 shows the flow chart for the main weighing routine and it will be seen that the first action taken is the running of a key handling routine F1. This routine, which is illustrated in Figure 6, looks at the keyboard map stored in RAM showing the state of the keys 5 - 11 and selects appropriate modes in accordance with the keys which have been pressed. Let us assume that initially no keys are pressed.

The exits of the key handling routine F1 return to the main routine of Figure 3 which proceeds to determine if a new, filtered, weight reading Wr has been received from the weighing device by way of the converter 22. In this respect, it will be recalled that weight readings are applied to the micro-processor 26 ten times a second. It will be clear from Figure 3 that if the decision at block D1 is made when no new weight reading has arrived, the program will loop back to decision D1. If a filtered weight reading Wr is received, that new weight reading will be stored in RAM 34 and the program will then move on to function F2. In this respect, the program at decision block D1 is arranged to determine not only that a new weight reading has been received, but also that the weight

reading has settled and has been filtered to remove the effects of vibration. Thus, at the decision block D1 the program effectively waits for a new, steady and filtered weight reading Wr to be received.

Stored in RAM 34 is a pan empty reading Wz which is representative of the weight signal received when the weighing platform 4 is empty. At block F2 the gross weight Wg on the platform 4 is determined by subtracting the pan empty weight Wz from the current weight reading Wr that is, Wg = Wr - Wz. This determined gross weight Wg is stored in RAM.

The routine then moves on to the decision block D2 where it determines if single tare has been selected, for example, by pressing the appropriate key 5, marked "T". This information will already have been stored in RAM by the key handling routine F1. If single tare has been selected function block F3 subtracts from the gross weight Wg the tare weight Wt stored in RAM to form the nett weight Wn, that is

$$Wn = Wg - Wt.$$

In this case, the key handling routine F1 will have already determined that none of the keys 5 to 11 has been pressed and accordingly the answer at the decision block D2 is "No". This leads the routine to block F4 in which the nett weight Wn is accorded the value of the gross weight Wg.

The nett weight Wn formed by either function F3 or F4, as appropriate, is then applied to decision block D3 where it is compared with zero track limits from the memory 32. These zero track limits give the readings below which the weighing platform is deemed to be empty. These zero track limits also set the readings below which adjustment of the stored pan empty reading occurs.

By way of example, let us assume that the stored pan empty reading Wz is 200. Let us also assume that the weighing platform 4 is empty and that the weight reading Wr received by the micro-processor 26 is 203. It will be apparent that the gross weight Wg computed by function F2 will be 3 and this will be assigned to the nett weight Wn by block F4. If the zero track limits are set say at 8, the nett weight Wn will be found by block D3 to be less than the limit. The "YES" answer at decision block D3 will therefore cause zero tracking to be performed by the function block F5.

In function block F5 a new pan empty reading Wz is computed from the original Wz reading and from the new weight reading Wr. The formula used is

New Wz = Old Wz x 0.95 + Wr x 0.05.

It will be appreciated that this formula causes a gentle adjustment to the original value of Wz to be made because the new value of Wz is strongly based on the old value with only a 5% adjustment for the new weight reading Wr. In the example given the adjusted value which is assigned to Wz in RAM will be 200.15 as compared to the 200 originally assigned thereto. By this means it is ensured that the value of Wz only undergoes considerable alteration in response to a trend, and that it is not adversely effected by spurious readings.

The pan empty reading Wz having been adjusted by block F5, the program moves on to decision block D4 in which the nett weight Wn is compared with pan empty limits stored in ROM 32. These are the weight limits below which the weighing platform is deemed to be empty. In the example given, these limits might be set, say, at 15. In the example given, the nett weight Wn has been accorded the value 3 and therefore

is well below the pan empty limits so that D4 gives a "YES" output. The routine has therefore correctly identified that the pan is empty and function block F6 thereby causes an appropriate pan empty message to be displayed by way of the display 30. Block F6A now sets an "OKTOADD" flag which is used later in the key handling routine at block D20, and block F6B resets to zero variables which are used in the COUNT routine of Figures 5A, 5B and 5C. At this point, as will be appreciated, the routine loops back to its start and thus can respond at F1 to any keys which have been pressed and at D1 to the receipt of a new weight reading.

If on running through the weighing routine of Figure 3 it is found that a weight has been placed on the platform 4, it will be appreciated that the nett weight Wn computed at either F3 or F4 will be more than the zero track limits of D3 and the pan empty limits of D4. In this case then, instead of looping back to the start, the routine will continue to decision block D5 in which the program looks to see which mode has been selected. If the key 6 marked "V" has been pressed the verify mode will have been selected and the verify program of Figure 4 will be run. Alternatively, if either of the keys 10 or 11, marked respectively "NOTES" and "COINS", have been pressed, the program will proceed to its count routine illustrated in Figures 5A, 5B and 5C.

Figure 4 illustrates the verifying routine which enables automatic verifying of standard packs of notes or coins. Initiation of this routine is by pressing the key 6. With this key pressed, and the weighing platform 4 empty, the verify mode is selected by the key handling routine F1, and the function block F6 of the main program will cause the message "VERIFY" to be displayed by the display 12. Thereafter, the placing

of a weight on the platform 4 will cause the machine automatically either to confirm the contents of the pack or to display a warning message "CHECK IT".

To perform the verify routine of Figure 4, additional information in the form of a list of the denominations of coins and notes which can be verified by the machine is stored in memory 32. As noted previously, for each denomination there is also stored a calibration weight Wc for that denomination, the number Nv of items of that denomination in a standard pack, and the tare weight Wt, that is, the weight of the packaging for that standard pack. If the coins or notes of any denomination are often packaged in more than one standard pack, that denomination may appear more than once in the list of denominations. Each entry for each denomination will, in this case be associated with data (Nv and Wt) relating to a respective standard pack.

The verifying routine is described and illustrated in International Application No. WO 88/09485, the contents of which are incorporated herein by reference. Accordingly, the details of the routine, which is illustrated in Figure 4, will not be further described herein.

As is also made clear in International Application No. WO 88/09485, the machine is particularly useful in that the standard packs placed on the platform 4 for their verification, can simultaneously have their values added. Thus, at the end of a verification run, the operator will not only have checked the accuracy and integrity of the contents of a series of standard packs, but will also have an accurate total of their value. This addition is performed by the key handling routine of Figures 6A, 6B and 6C which is initiated by function F1 of the main program. The addition performed by the key handling routine is described in

detail in International Application No. WO 88/09485 and so is not further described in detail herein.

The machine has various tare facilities, including a "multiple tare" facility enabling packaged items, for example, bags or rolls of coins to be weighed singly. The appropriate tare facility is selected by the key handling routine of Figures 6A, 6B and 6C which will now be described.

It will be recalled that the key handling routine illustrated in Figures 6A, 6B and 6C is initiated by function F1 of the main program. Its first step is to look at the map of pressed keys stored in RAM. The first decision block D8 then determines if the key 10, labelled "NOTES" is the only key pressed. If the key 10 has not been pressed, or has been pressed but in conjunction with other keys, the key handling routine continues along the route marked "NO" to consider the status of the other keys. If the output of block D8 is "YES" the program proceeds to block D9 which determines if the platform 4 is empty, this information being available from the function block F6 of the main program. If the platform is not empty, for example because a previous count or verifying routine is being completed, the routine exits through "EXIT 1", clearing the map of pressed keys stored in RAM before returning to the start of the main program of Figure 3. If the key 10 is pressed with the platform 4 empty, the key handling routine by way of blocks D8, D9 and D10 will select the count mode and enter that selection in RAM. It will be seen that the function block F17 also selects "notes", selects the first denomination of notes in the list of denominations stored in RAM, and selects "loose notes". The denomination so selected will be displayed on the panel 12 and the other selections can similarly be displayed. This routine then exits by way of "EXIT 1" and a function block F20,

which clears the stored key map, to the main program.

If the denomination selected by the block F17 is the denomination in which it is required to count, a count routine can then be initiated simply by placing the notes to be counted on the platform 4. However, if the block F17 has selected a denomination which is not required, the "NOTES" key 10 is repeatedly pressed and released until the denomination required has been selected and is displayed. It will be appreciated that every time the key 10 is pressed with the count notes mode already selected, the decision block D10 of the key handling routine will cause by way of a decision block D11 and function blocks F18 and F19 the selection of a different denomination in the list. Each selected denomination is displayed and so the operator continues to press and release the key 10 until the appropriate denomination is displayed. The count routine can then be commenced by placing the notes on the platform 4.

The key handling routine includes an analogous routine for selecting the count mode and the denomination when coins are to be counted. This routine is accessed by pressing only the key 11, labelled "COINS", as is indicated by the decision block D8c. The remaining decisions and functions of the coin count routine have been given references the same as those of the note count routine with the addition "C". Each decision or function block of the coin count routine performs a similar function or makes a similar decision as the corresponding block in the notes count routine. However, it will be seen that the function block 17c which selects coins, count mode, and the first denomination also selects "Bag Mode" which is the multiple tare facility.

If both the "NOTES" key 10 and the key 5 marked "T" are pressed together a decision block D12 leads to a function block F21 which selects a full calibration

mode. This mode, which enables the information stored in RAM to be calibrated will not be described herein. Similarly, pressing both the "COINS" key 11 and the key 5 causes a decision block D13 to proceed to a function block F22 which selects a recalibration mode. This mode enables calibration of selected information in RAM and again will not be further described herein.

If the key 5 marked "T" is pressed alone decision block D14 (Figure 6C) leads into a tare select mode. In this mode, if block D15 finds the platform is not empty a manual tare routine is initiated to enable the weight of a container or wrapper to be measured and recorded before the weighing routine is commenced. In this manual mode, the container is placed on the platform 4 before the key 5 "T" is pressed. Because the platform is not empty decision block D15 leads to a set manual tare sub-routine in which the contents of the platform are weighed, F24, this weight Wt is stored in RAM as the tare weight, F25, and then manual tare mode is selected, F26. When a weighing routine is subsequently performed by the main program the tare weight Wt which has been stored will be subtracted from the gross weight Wg at function block F3, but this will be the tare weight established by functions F24 and F25.

If in the tare select mode, the decision block D15 finds that the platform 4 is empty, the routine moves to decision block D15A to establish if notes or coins have been selected. It will be recalled that this was set by function block F17 or F17C when an appropriate count mode and denomination was selected. If notes has been selected at function block F17, "loose notes", that is a count routine without a tare facility, will also have been selected. The decision at decision block D15B will therefore be "NO" causing function

block F23A to respond to the fact that the key 5 "T" has been pressed to select stored tare mode. It has already been seen that in the main program this causes the tare weight Wt to be subtracted from the gross weight Wg. It will be appreciated that if the key "5" marked "T" is not pressed after a notes count routine, and the appropriate denomination have been selected, function block F17 will have selected "loose notes", that is a count routine without a tare facility so that function block F4 of the main program sets the nett weight Wn equal to the gross weight Wg.

The decision block D15B enables the selection of the stored tare mode to be cancelled by pressing the key 5 "T" a second time so that the decision "Yes" at decision block D15B causes the function block F23B to clear all tares. It will be appreciated that pressing the key 5 repeatedly with the platform empty will cause the stored tare and loose notes modes to be selected alternately.

Where coins have been selected by function block F17C "Bag Mode" is automatically selected. We have seen that this can be changed to the manual tare mode by pressing the key 5 "T" with a coin tray or other container on the platform 4. If the tare mode needs to be changed from the manual tare mode selected back to "Bag Mode" this is achieved by pressing the key "T" with the platform empty so that function block F23C selects the "Bag Mode".

The other routines of the key handling routine illustrated in Figures 6A, 6B and 6C are described in detail in International Application No. WO 88/09485 and so are not further described herein.

As will be apparent from the descriptions given above, the machine has a normal count routine by which it is able to determine the number of notes or coins of

a selected denomination which have been placed on the platform 4. This count routine, which is illustrated in Figures 5A, 5B and 5C, enables the value of the items on the platform 4 to be determined whether the items are packaged or not. Function block F36 selects the weight Wc in RAM calibrated for the particular denomination which is being counted. At decision block D30 it is then decided if multiple tare has been selected, this being the "Bag Mode" of function blocks F17C and F23C. If the multiple tare facility has not been selected, the routine moves on to function block F37 at which the number of items on the platform 4 is determined by dividing the nett weight by the calibration weight, that is

$$N = Wn \div Wc.$$

It will be appreciated that the nett weight Wn has already been determined at function block F3 or F4 of the main weighing routine of Figure 3. In this respect, if either manual tare mode or stored tare mode has been selected, decision block D2 causes function block F3 to calculate the nett weight by subtracting the appropriate tare weight.

The routine then proceeds to block D25 to determine whether notes or coins are being counted. This, together with the denomination being counted, has already been selected by the operator, who has pressed either the "NOTES" key 10 or the "COINS" key 11 at the start of a weighing process. If coins are being counted the routine passes to function block F38 where the calculated number N of items on the pan is rounded to the nearest integer Nd. For example, if N is calculated at block F37 to be 23.87, then Nd is set to 24. At the subsequent function block F39 the value V

of the coins on the pan is calculated by multiplying the integer number Nd of coins on the pan by the denomination of those coins. For example, if the selected denomination is 20 pence coins, the value V will be 24 x 0.2 pounds, i.e. £4.80. Function block F40 then causes a suitable display of the determined value V, preferably with the selected denomination, to be made on the display panel 12. With the example given, the display might read "20p, £4.80". The routine then returns to the START of the main weighing routine of Figure 3.

If at decision block D25 of the count routine it is determined that notes are being counted, the routine passes to block F41 where Na, the number Na of notes added this time is calculated. In this respect, Na is determined by subtracting from the number of notes N determined at block F37 as being on the pan a number No. This number No was the number of notes calculated at block F37 during the immediately preceding pass through the count routine and stored. Thus,

$$Na = \left| N - No \right|$$

At function block F42 the number Na of notes added is rounded to the nearest integer Na'. At decision block D26 the routine determines if any notes have been added to the pan since the last pass through the routine by asking is Na' greater than zero? If Na' is equal to zero then no further notes have been added and the routine returns to the START of the main weighing routine of Figure 3, and makes no changes to the display.

If notes have been added, Na' will be greater than zero. When this is determined at decision block D26, the routine moves onto decision block D27 which

determines if the number of notes added exceeds a preselected maximum number. In the illustrated embodiment, this maximum number has been chosen to be twenty-five which has been found to represent a good compromise between the requirement of accepting as many notes as possible, and the requirement of not displaying an incorrect result. Other numbers can be chosen to produce differing compromises of the above requirements without affecting the procedure. If Na', the rounded number of notes added, is greater than 25 then a warning message TRY LESS is caused to be displayed at block F45 and the routine returns to the START of the main weighing routine of Figure 3.

If it is determined at the decision block D27 that 25 or less notes have been added, the routine passes to function block F43 at which appropriate error band limits for the rounding are selected. In the particular embodiment illustrated, the rounded integer Na' is used to select a particular set of error band limits from an Error Band Table which is stored within the memory 32. The error band limit range is generally decreased as the integer Na' increases as explained in more detail in our copending application No. PCT/GB89/00630.

At block D28 the fractional part of Na, the number of notes added, is compared with the limits determined at block F43. If the fractional part of Na is within the error band limits then the result is in error and is not acceptable and a warning message TRY LESS is arranged to be displayed by the block F45 and then the routine returns to the START of the main weighing routine of Figure 3.

If at block D28 the fractional part of Na is outside the error band limits, the result is acceptable and the routine passes on to block F44 to commence a

stacking error correction arranged to remove cumulative errors from the weighing of successive additions of notes.

The stacking error correction routine is similar to that described and illustrated in our UK patent No. 2076979 and removes the risks of cumulative errors occurring because the notes are being weighed in successive bundles. To explain the operation, assume that each item to be weighed has a calibrated weight of 10 grams, but an actual weight of 10.15 grams. A first bundle of 25 items will weigh 253.75 grams, and the resultant quotient N of 25.375 will be correctly rounded to 25. A second bundle of 25 items placed on the first will successfully meet the error band criteria of decision block D28, but the cumulative weight of 507.50 grams, and the resultant quotient of 50.75 would be incorrectly rounded to 51.

This sort of error is obviated by the stacking error correction routine. At function block F44 a stacking correction factor G is subtracted from the quotient N representing the total number of notes calculated at block F37. By this means a corrected number Nc of items on the pan is formed, where

$$Nc = N - G.$$

Initially, as we saw in the main weighing routine of Figure 3, the stacking correction factor G is zero.

The corrected number Nc is then rounded to the nearest integer Nd at function block F46. It will be appreciated that Nd represents the total number of items on the pan.

The routine next passes to function block F47 where a new stacking correction factor G is calculated as the difference between the corrected integer number

of notes on the pan, Nd, and the calculated number N of notes on the pan from block F37.

i.e. $G = N - Nd$

The new stacking correction factor G having been stored, the routine passes to block F48 where the value V of the notes of the pan is calculated by multiplying the number of notes on the pan by their denomination. That is:

$$V = Nd \times \text{denomination}$$

This calculated value V is then caused to be suitably displayed on the display panel 12 by way of function block F49. In this respect, the display could be of value only or of denomination and value, for example, the display could be "£5, £250".

The routine then performs an updating of the calibrated weight Wc, and the new value for Wc is stored in RAM in place of the old value. The updating is performed at function block F50 and is arranged to modify the calibration weight Wc of the selected denomination in such a way as to reduce the difference between the stored calibration weight Wc and the real average weight of the notes being counted. In the embodiment illustrated the new value for Wc is calculated according to the formula:

$$\text{New Wc} = \text{Old Wc}\,(1-0.0005\text{Na}') + (\text{Wn} - \text{Wo})\ 0.0005$$

Where Wn is the nett weight on the pan, and Wo is the old nett weight on the pan, that is the nett weight at the immediately preceding pass through the count routine of Figures 5A, 5B and 5C.

It will be seen that this formula takes account of the number of notes added each time as well as their average weight. The effect of thus modifying the calibration weight is to enable the machine to track slow changes in the average weight of the notes being counted. In this respect, it will be appreciated that it is important to continuously update the stored weight Wc for notes because notes can vary significantly in their weight depending upon whether they are old or new, if they have been damaged, or subject to humidity and the like. It would be possible to recalibrate the weight reading stored for the coins, but this is not generally necessary.

At block F51 the old number of notes on the pan, No, is updated to be the current number of notes on the pan and at block F52 the old weight on the pan, Wo, is updated to be the current weight on the pan and then the routine returns to the START of the main weighing routine shown in Figure 3.

We have already seen that a multiple tare facility may be selected at function blocks F17C and F23C of the key handling routine. If this facility is selected a routine which automatically determines the number of containers in which coins are packaged so that these containers can be allowed as a tare weight is initiated by the decision block D30.

In the embodiment of the multiple tare facility particularly described and illustrated the following assumptions are made:

1. When using the multiple tare facility, the coins will be put onto the platform 4 in nominally full containers and there will be no loose coins.

2. Containers will not be overfilled by more than

two coins, and any excess over the standard quantity will be in a separate container.

Thus if a nominally full container contains 20 coins and the machine determines that there are 124 coins, the machine will determine that there are 6 full containers of 20 coins and a seventh container of 4 coins.

Of course, other assumptions may be made if required. For example, it could alternatively be assumed that all odd coins are loose rather than being in a further container.

If the multiple tare facility has been selected a "YES" at decision block D30 moves the routine to function block F55 which is at the commencement of an iterative process to calculate the tare weight to be allowed for the containers. Block F55 calculates the standard weight FCW of one container or packaging for the standard pack of the selected denominated. As shown, the weight FCW is calculated by multiplying the standard number of items per pack Np by the weight Wc of each item and then adding the weight Wp of the empty container or packaging, that is:

$$FCW = Np \times Wc + Wp$$

The routine then passes to function block F56 where a variable y is equated to the gross weight Wg and a counter for the number of containers Nr is set to 1. The routine then passes onto decision block D31 which compares the weight y with the standard weight FCW of one container plus the weight of two items. Thus, at decision block D31 the following question is asked:

$$y > FCW + 2Wc?$$

The choice of two items at this point is made because of the assumed requirement allowing a container to be overfilled by two items before allowance is made for a further container. Other numbers can of course be chosen to produce differing limit points as required.

If the answer at block D31 is "YES" then the routine passes to a function block F58 where the number of containers Nr is incremented by one, that is, $Nr = Nr + 1$. The routine then moves to block F59 where the weight FCW of one standard full container is deducted from y. That is,

$$y = y - FCW.$$

The routine then returns to block D31 to repeat the comparison, and the routine continues to loop through blocks D31, F58 and F59 are repeated until the answer at block D31 is "NO".

It will be appreciated that each time the routine passes around the loop the counter giving the number of containers is incremented by one, F58, whilst the variable y is reduced by the weight of one full container. When y becomes less than the limiting weight the number of containers is taken as the value then set for Nr and at block F57 the nett weight Wn calculated by subtracting from the gross weight the weight of the calculated number of containers. That is,

$$Wn = Wg - Nr \times Wp$$

Having calculated the nett weight Wn the routine then passes to function block F37 where the count

routine already described hereinbefore proceeds.

It will be appreciated that modifications of and variations in the present invention as described and illustrated may be made. For example, in the embodiment illustrated, only the coin count routine embodies a multiple tare facility. Clearly a similar multiple tare facility could be provided for the note count routine, either as an alternative to, or in addition to, that provided for coins.

It will be appreciated that the provision of the functions described above through appropriate software will be within the ability of those skilled in the art and requires no detailed explanation.

Many modifications and variations of the invention as specifically described above may be made within the scope of the invention. In particular, the invention may be applied to the weighing and counting of items other than coins or notes, and the items to be counted or weighed need not be representative of money's worth. Furthermore, the apparatus may be arranged to perform routines other than those specifically described.

The multiple tare facility may also be provided independently of the other routines, for example, of the count and verify routines, described above.

CLAIMS

1. Apparatus for determining the number and/or value of items packaged in one or more packages, said apparatus comprising processor means arranged to receive a weight signal representative of the total weight of the packages, said processor means having means for calculating from said weight signal a tare allowance representative of the weight of the packaging of said packages, and means for subtracting the calculated tare allowance from said weight signal to form a nett weight signal representative of the weight of the items.

2. Apparatus as claimed in Claim 1, wherein said means for calculating said tare allowance comprises means for dividing said weight signal by an appropriate preset value to form a quotient, and means for multiplying a preset tare value representative of the weight of the packaging by said quotient to form said tare allowance.

3. Apparatus as claimed in Claim 2, wherein said quotient is formed by repeatedly subtracting said preset value from said weight signal, and incrementing a counter for each said subtraction, until said weight signal is smaller than said preset value, and the contents of the counter then providing said quotient.

4. Apparatus as claimed in Claim 2 or 3, wherein the preset value by which said weight signal is divided may be representative of the weight of the items in a single package or of the total weight of one package such that said quotient is at least approximately representative of the number of packages, and said preset tare value is representative of the weight of the packaging of a single package.

5. Apparatus as claimed in any preceding claim, wherein said processor means further comprises means for dividing said nett weight signal by an appropriate weight factor to determine the number and/or value of said items.

6. Weighing apparatus for determining the number and/or value of weighed items, said apparatus comprising means for producing a weight signal, and apparatus as claimed in any preceding claim for determining the number and/or value of packaged items and arranged to receive said weight signal, wherein means are provided for determining the number and/or value of the weighed items for said nett weight signal.

7. Weighing apparatus as claimed in Claim 6, wherein said means for determining the number and/or value of the weighed items comprises means for dividing said nett weight signal by an appropriate weight factor.

8. Weighing apparatus as claimed in Claim 6 or 7, wherein said means for producing the weight signal comprises weighing means for producing an actual measured weight.

9. Weighing apparatus as claimed in Claim 7, arranged to weigh items of different denominations, each denomination representing a different value, said weighing apparatus comprising storage means in which a list of denominations is stored together with the value assigned to each denomination, and a respective weight factor for each denomination in the list, wherein each said weight factor is representative of the weight of a respective predetermined number of the items of that denomination.

10. Weighing apparatus as claimed in Claim 9, wherein said processor means has means for dividing said nett weight signal by a selected weight factor to form a quotient representative of the number of items being weighed, means for comparing said quotient with tolerance limits, and output means for signalling that said quotient is within said tolerance limits and so acceptable or that said quotient is outside said tolerance limits and so unacceptable, and wherein said processor means is arranged to be responsive to said output means signalling that said quotient is acceptable to enable multiplying means to multiply at least part of said quotient by the value assigned to said denomination whereby the value of the weighed items is determined.

11. Weighing apparatus as claimed in Claim 10, wherein when said quotient is acceptable an appropriate exact integer value therefor is formed, and it is said exact integer value which is multiplied by said multiplying means with said assigned value.

12. Weighing apparatus as claimed in any of Claims 6 to 11, comprising a weighing platform for receiving items to be weighed, said means for producing a weight signal being coupled to said weighing platform so that said weight signal is representative of the weight of items on said platform, and input means to which said processor means is responsive to enable the selection of a weighing routine.

13. Weighing apparatus as claimed in Claim 12, wherein said input means comprises a keyboard, and wherein said output means comprises a display.

14. Weighing apparatus as claimed in any of Claims 6 to 13, wherein said processor means comprises a

microprocessor and said storage means is constituted by at least one memory.

15. A method of determining the number and/or value of items packaged in one or more packages, the method comprising the steps of calculating a tare allowance from a weight signal representative of the total weight of the packages, and subtracting the calculated tare allowance from said weight signal to form a nett weight signal representative of the weight of the items.

16. A method as claimed in Claim 15, wherein said weight signal is divided by a preset value representative of the weight of said items to form a quotient, and a preset tare value representative of the weight of the packaging is multiplied by said quotient to form said tare allowance.

17. Weighing apparatus substantially as hereinbefore described with reference to the accompanying drawings.

18. A method of determining the number and/or value of articles substantially as hereinbefore described with reference to the accompanying drawings.

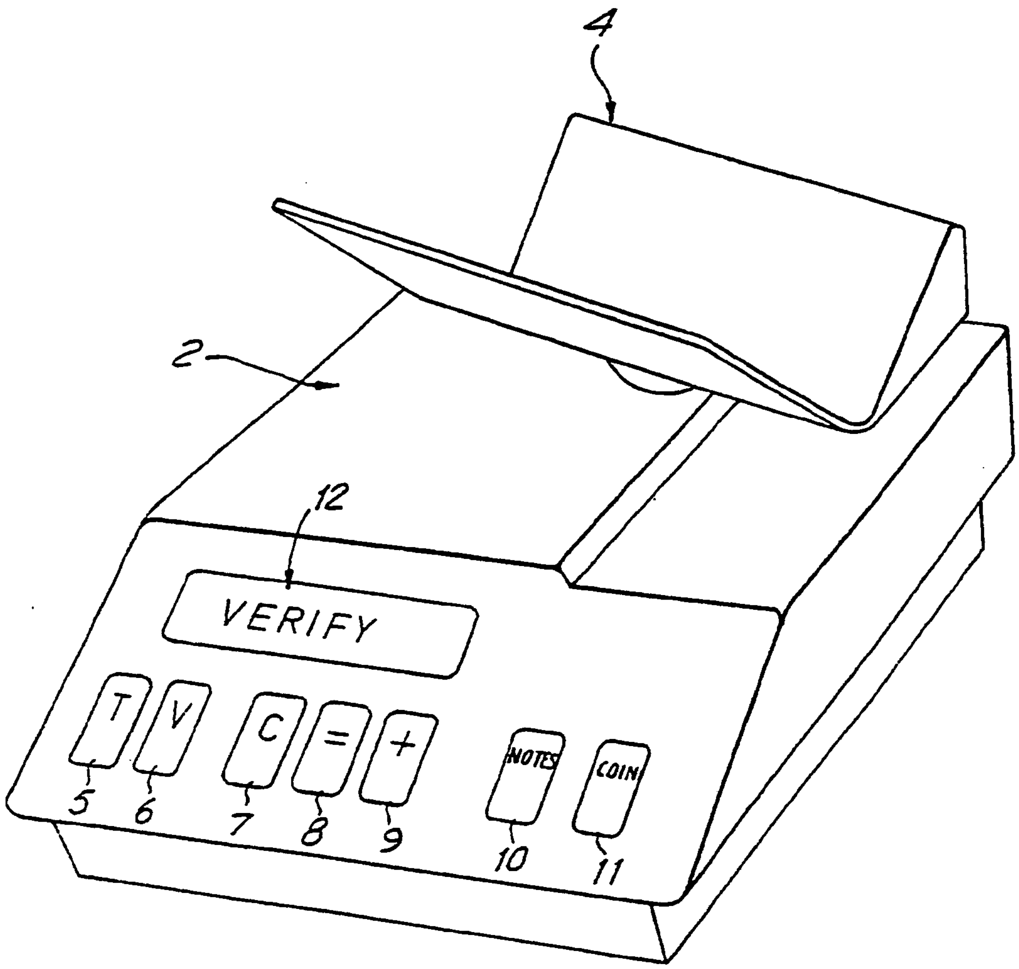


FIG.1

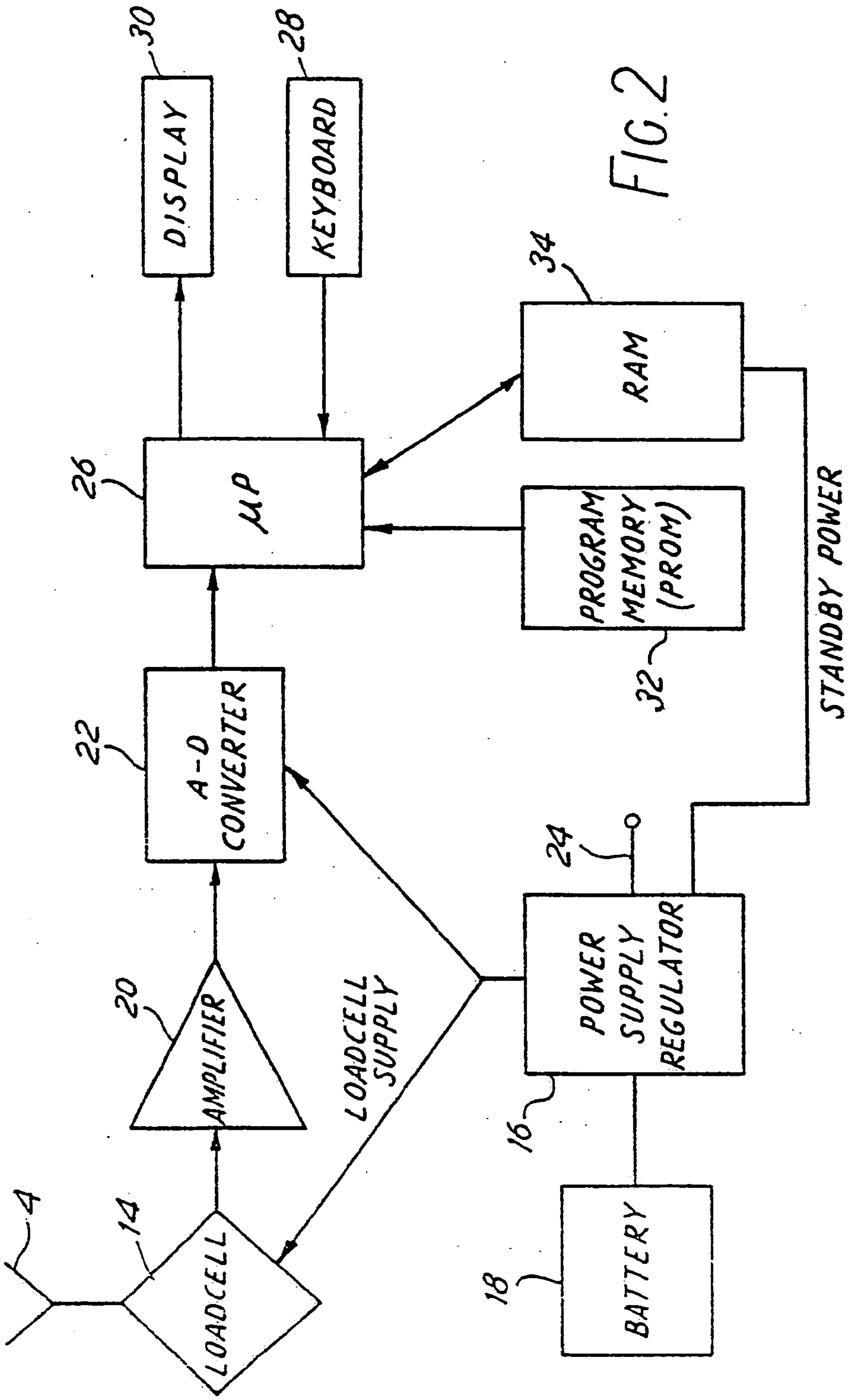

DISPLAY
KEYBOARD
RAM
μP
PROGRAM MEMORY (PROM)
STANDBY POWER
A-D CONVERTER
AMPLIFIER
LOADCELL SUPPLY
POWER SUPPLY REGULATOR
LOADCELL
BATTERY
30
28
34
26
32
22
24
20
16
14
4
18

FIG. 2

3/10

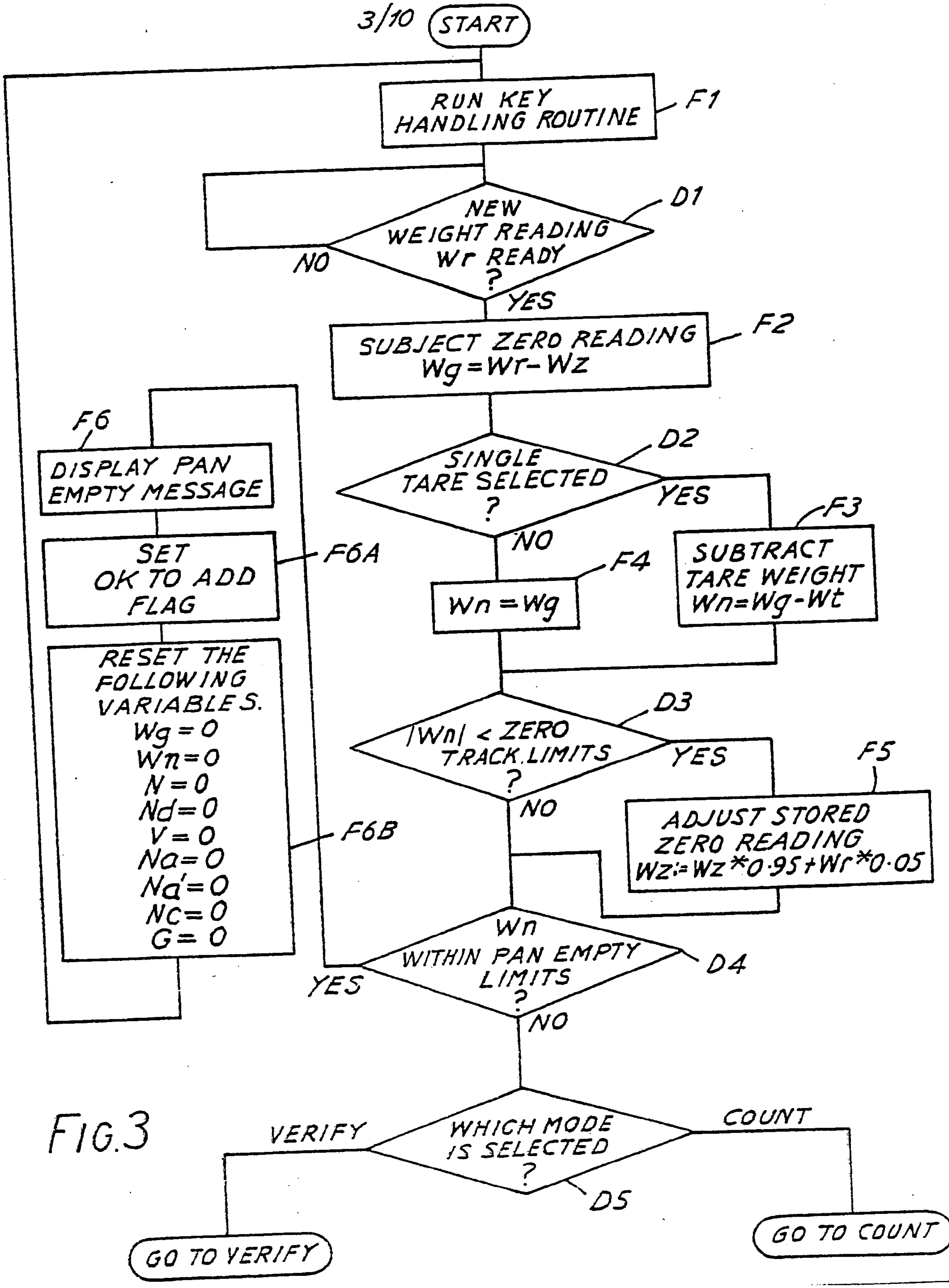

START
RUN KEY HANDLING ROUTINE
F1
NEW WEIGHT READING Wr READY ?
D1
NO
YES
SUBJECT ZERO READING Wg=Wr-Wz
F2
SINGLE TARE SELECTED ?
D2
YES
NO
SUBTRACT TARE WEIGHT Wn=Wg-Wt
F3
Wn=Wg
F4
|Wn| < ZERO TRACK LIMITS ?
D3
YES
NO
ADJUST STORED ZERO READING Wz:=Wz*0·95+Wr*0·05
F5
Wn WITHIN PAN EMPTY LIMITS ?
D4
YES
NO
F6
DISPLAY PAN EMPTY MESSAGE
SET OK TO ADD FLAG
F6A
RESET THE FOLLOWING VARIABLES. Wg=0 Wn=0 N=0 Nd=0 V=0 Na=0 Na'=0 Nc=0 G=0
F6B
WHICH MODE IS SELECTED ?
D5
VERIFY
COUNT
GO TO VERIFY
GO TO COUNT

FIG.3

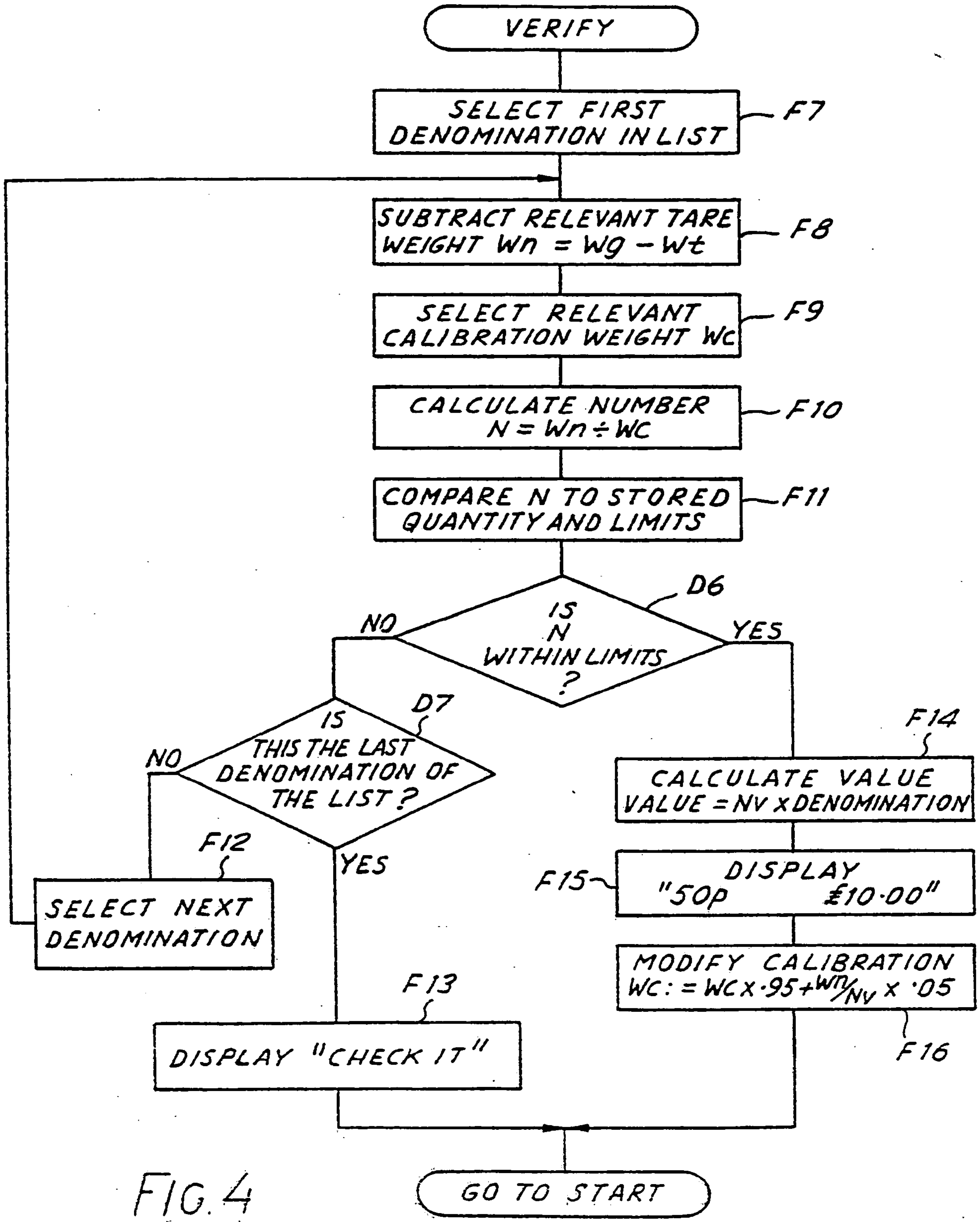

VERIFY
SELECT FIRST DENOMINATION IN LIST
F7
SUBTRACT RELEVANT TARE WEIGHT Wn = Wg − Wt
F8
SELECT RELEVANT CALIBRATION WEIGHT Wc
F9
CALCULATE NUMBER N = Wn ÷ WC
F10
COMPARE N TO STORED QUANTITY AND LIMITS
F11
IS N WITHIN LIMITS ?
D6
NO
YES
IS THIS THE LAST DENOMINATION OF THE LIST ?
D7
NO
YES
F12
SELECT NEXT DENOMINATION
F13
DISPLAY "CHECK IT"
F14
CALCULATE VALUE VALUE = NV x DENOMINATION
F15
DISPLAY "50p £10·00"
MODIFY CALIBRATION WC: = WC x ·95 + Wn/Nv x ·05
F16
GO TO START

FIG. 4

5/10

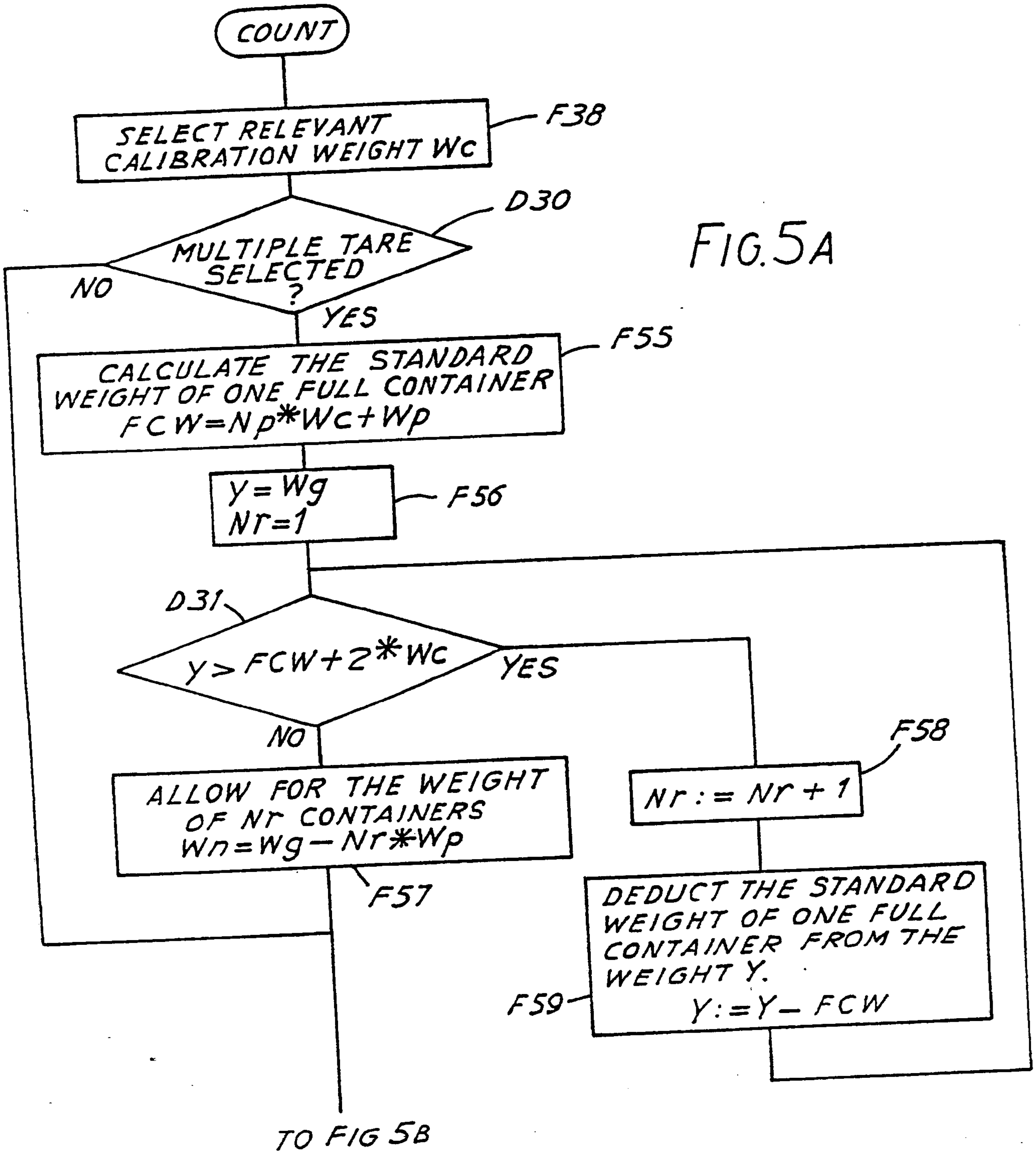
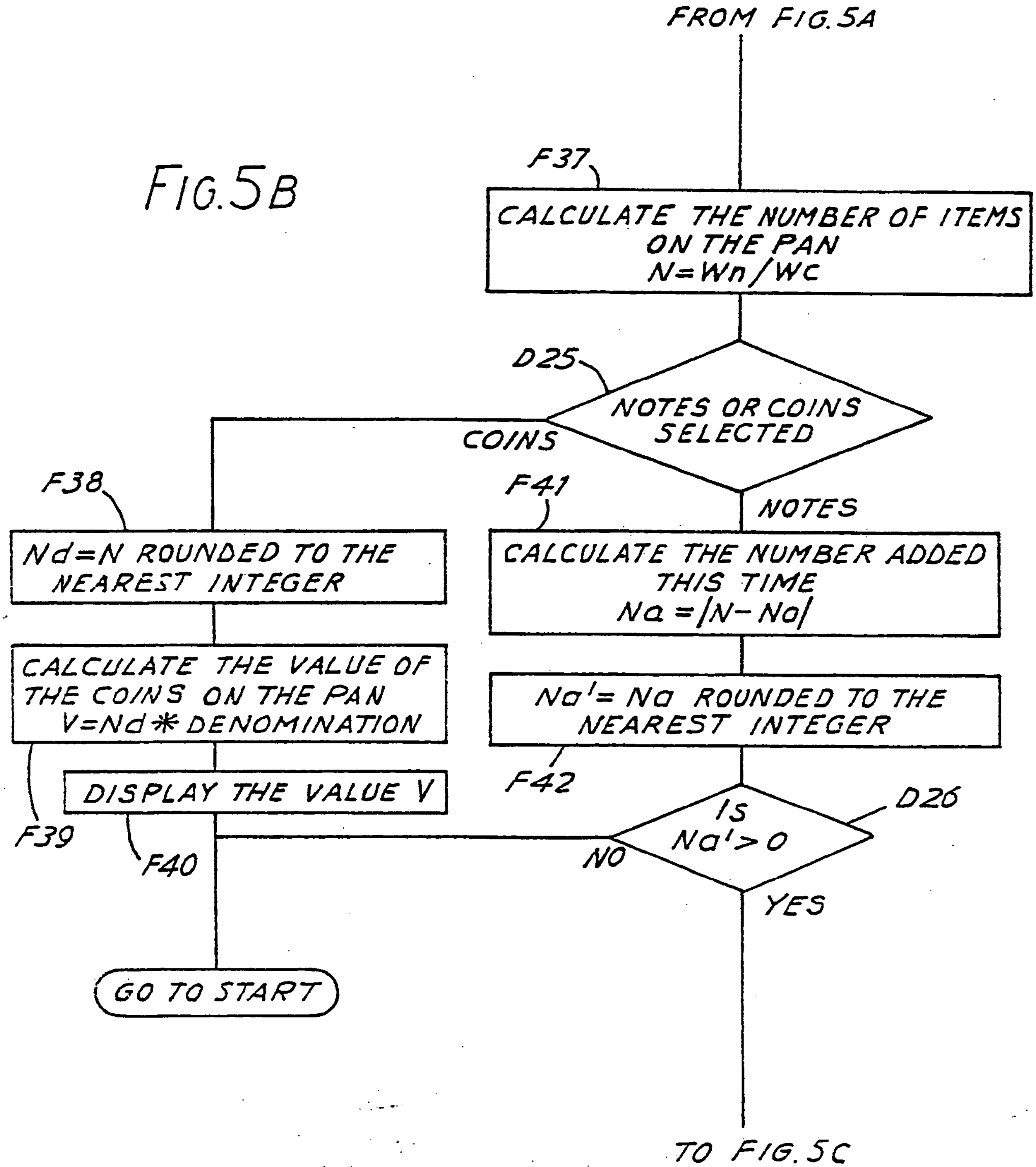

COUNT
SELECT RELEVANT CALIBRATION WEIGHT Wc
F38
MULTIPLE TARE SELECTED ?
D30
NO
YES
CALCULATE THE STANDARD WEIGHT OF ONE FULL CONTAINER FCW=Np*Wc+Wp
F55
y=Wg Nr=1
F56
D31
y>FCW+2*Wc
YES
NO
F58
Nr:=Nr+1
ALLOW FOR THE WEIGHT OF Nr CONTAINERS Wn=Wg−Nr*Wp
F57
DEDUCT THE STANDARD WEIGHT OF ONE FULL CONTAINER FROM THE WEIGHT Y. Y:=Y−FCW
F59
TO FIG 5B

FIG.5A

FIG.5B


FROM FIG.5A
F37
CALCULATE THE NUMBER OF ITEMS ON THE PAN N=Wn/Wc
D25
NOTES OR COINS SELECTED
COINS
NOTES
F38
Nd=N ROUNDED TO THE NEAREST INTEGER
F41
CALCULATE THE NUMBER ADDED THIS TIME Na=|N-No|
CALCULATE THE VALUE OF THE COINS ON THE PAN V=Nd*DENOMINATION
Na'=Na ROUNDED TO THE NEAREST INTEGER
F42
DISPLAY THE VALUE V
F39
F40
IS Na'>0
D26
NO
YES
GO TO START
TO FIG.5C

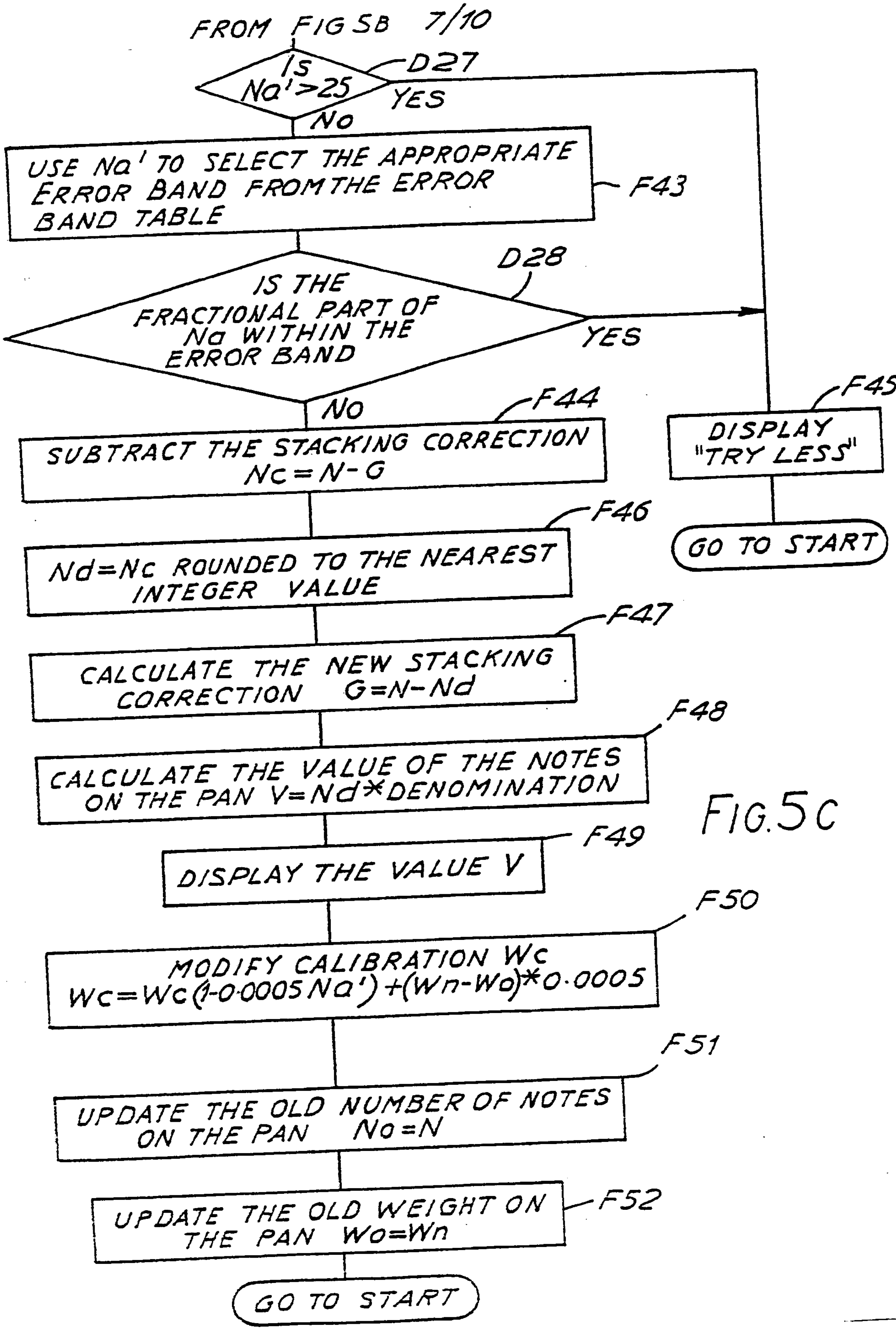

FROM FIG 5B
IS Na' > 25
D27
YES
NO
USE Na' TO SELECT THE APPROPRIATE ERROR BAND FROM THE ERROR BAND TABLE
F43
D28
IS THE FRACTIONAL PART OF Na WITHIN THE ERROR BAND
YES
NO
F44
SUBTRACT THE STACKING CORRECTION Nc=N-G
F45
DISPLAY "TRY LESS"
GO TO START
F46
Nd=Nc ROUNDED TO THE NEAREST INTEGER VALUE
F47
CALCULATE THE NEW STACKING CORRECTION G=N-Nd
F48
CALCULATE THE VALUE OF THE NOTES ON THE PAN V=Nd*DENOMINATION
F49
DISPLAY THE VALUE V
F50
MODIFY CALIBRATION Wc Wc=Wc(1-0.0005Na')+(Wn-Wo)*0.0005
F51
UPDATE THE OLD NUMBER OF NOTES ON THE PAN No=N
F52
UPDATE THE OLD WEIGHT ON THE PAN Wo=Wn
GO TO START

FIG.5C

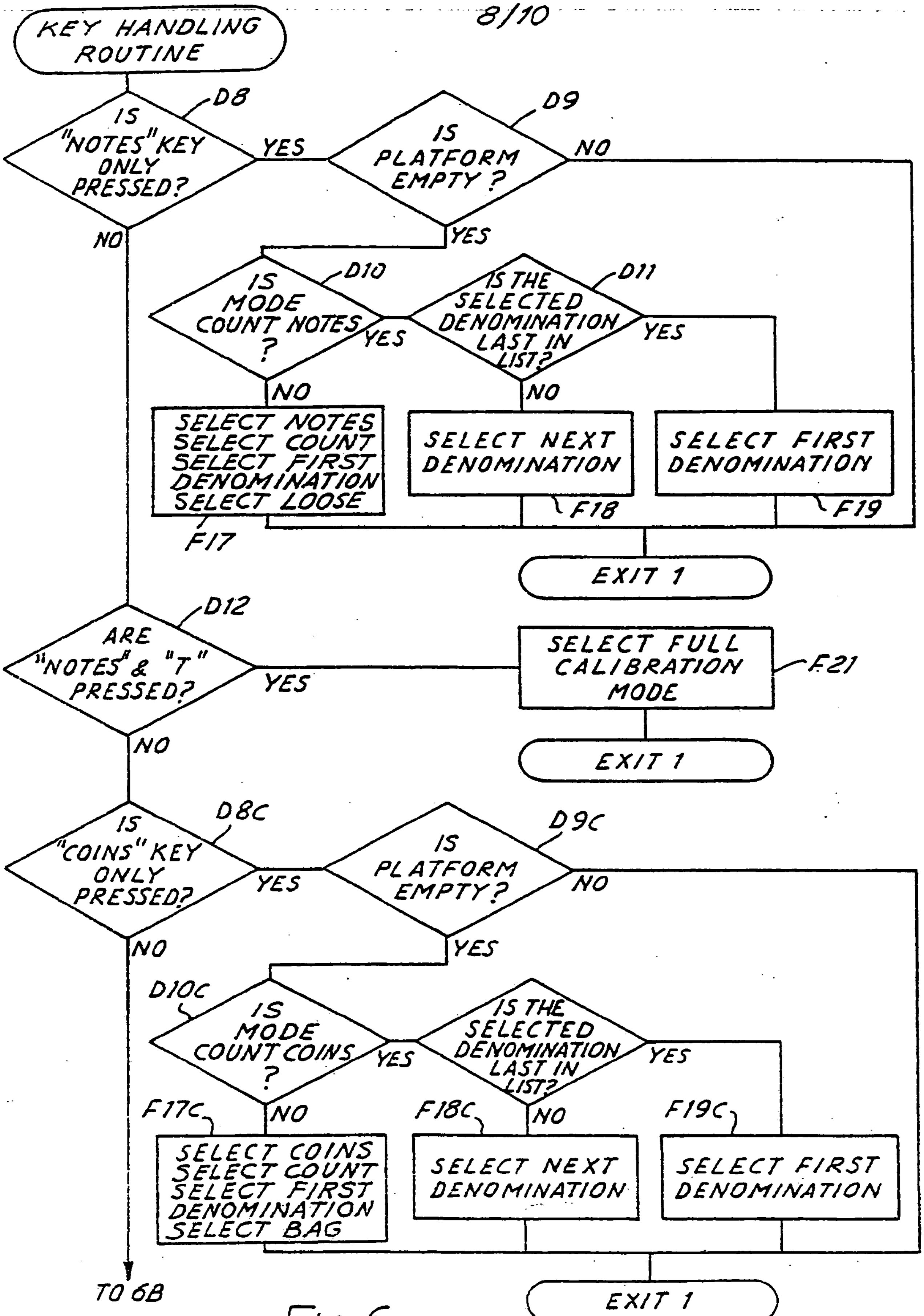

KEY HANDLING ROUTINE
D8
IS "NOTES" KEY ONLY PRESSED?
YES
NO
D9
IS PLATFORM EMPTY ?
NO
YES
D10
IS MODE COUNT NOTES ?
YES
NO
D11
IS THE SELECTED DENOMINATION LAST IN LIST?
YES
NO
SELECT NOTES SELECT COUNT SELECT FIRST DENOMINATION SELECT LOOSE
F17
SELECT NEXT DENOMINATION
F18
SELECT FIRST DENOMINATION
F19
EXIT 1
D12
ARE "NOTES" & "T" PRESSED?
YES
NO
SELECT FULL CALIBRATION MODE
F21
EXIT 1
D8C
IS "COINS" KEY ONLY PRESSED?
YES
NO
D9C
IS PLATFORM EMPTY?
NO
YES
D10C
IS MODE COUNT COINS ?
YES
NO
IS THE SELECTED DENOMINATION LAST IN LIST?
YES
NO
F17C
SELECT COINS SELECT COUNT SELECT FIRST DENOMINATION SELECT BAG
F18C
SELECT NEXT DENOMINATION
F19C
SELECT FIRST DENOMINATION
TO 6B
EXIT 1

FIG.6A

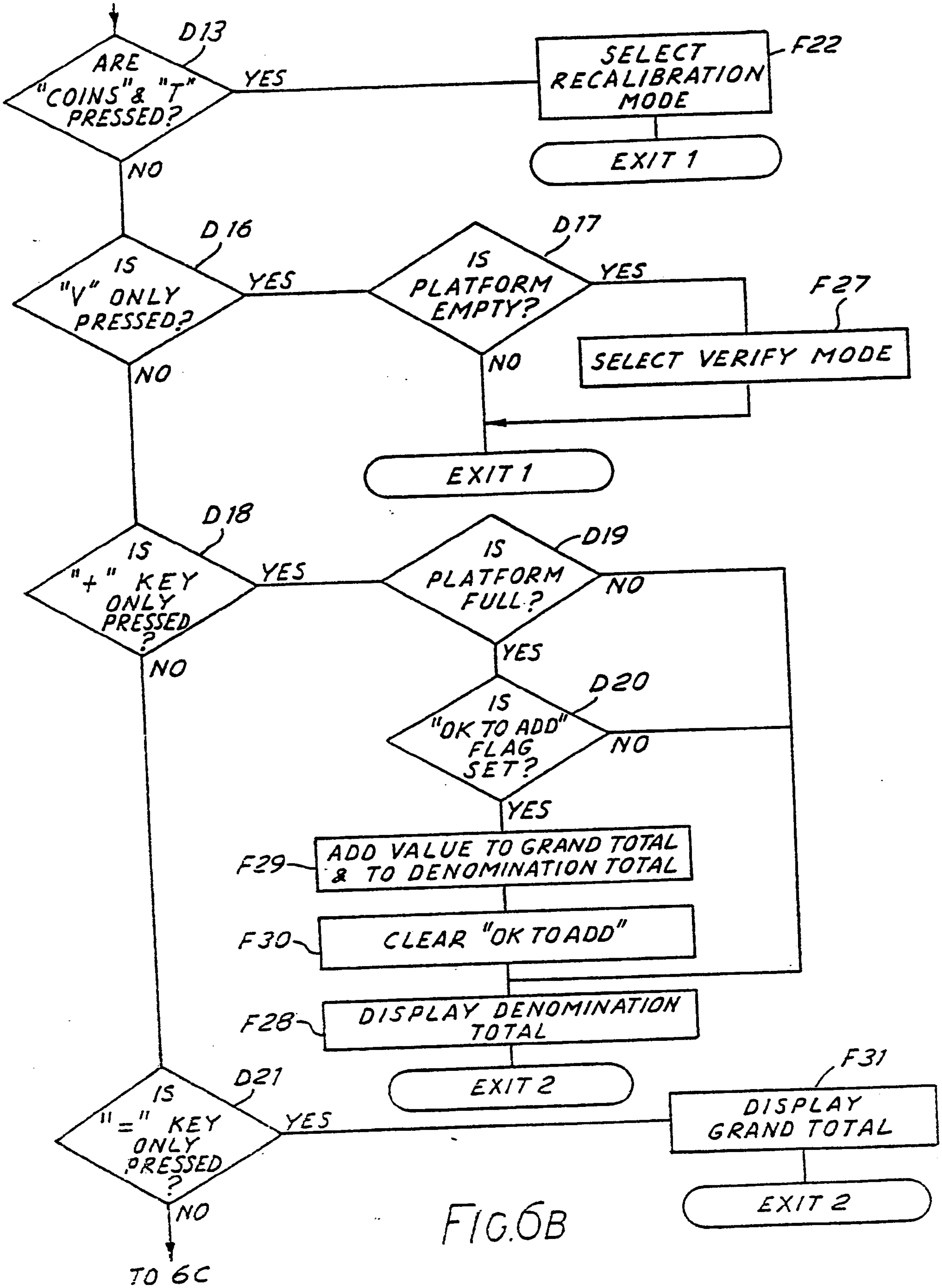

D13
ARE "COINS" & "T" PRESSED?
YES
NO
SELECT RECALIBRATION MODE
F22
EXIT 1
D16
IS "V" ONLY PRESSED?
YES
NO
D17
IS PLATFORM EMPTY?
YES
NO
F27
SELECT VERIFY MODE
EXIT 1
D18
IS "+" KEY ONLY PRESSED ?
YES
NO
D19
IS PLATFORM FULL?
NO
YES
D20
IS "OK TO ADD" FLAG SET?
NO
YES
F29
ADD VALUE TO GRAND TOTAL & TO DENOMINATION TOTAL
F30
CLEAR "OK TO ADD"
F28
DISPLAY DENOMINATION TOTAL
EXIT 2
D21
IS "=" KEY ONLY PRESSED ?
YES
NO
F31
DISPLAY GRAND TOTAL
EXIT 2
TO 6C

FIG.6B

10/10

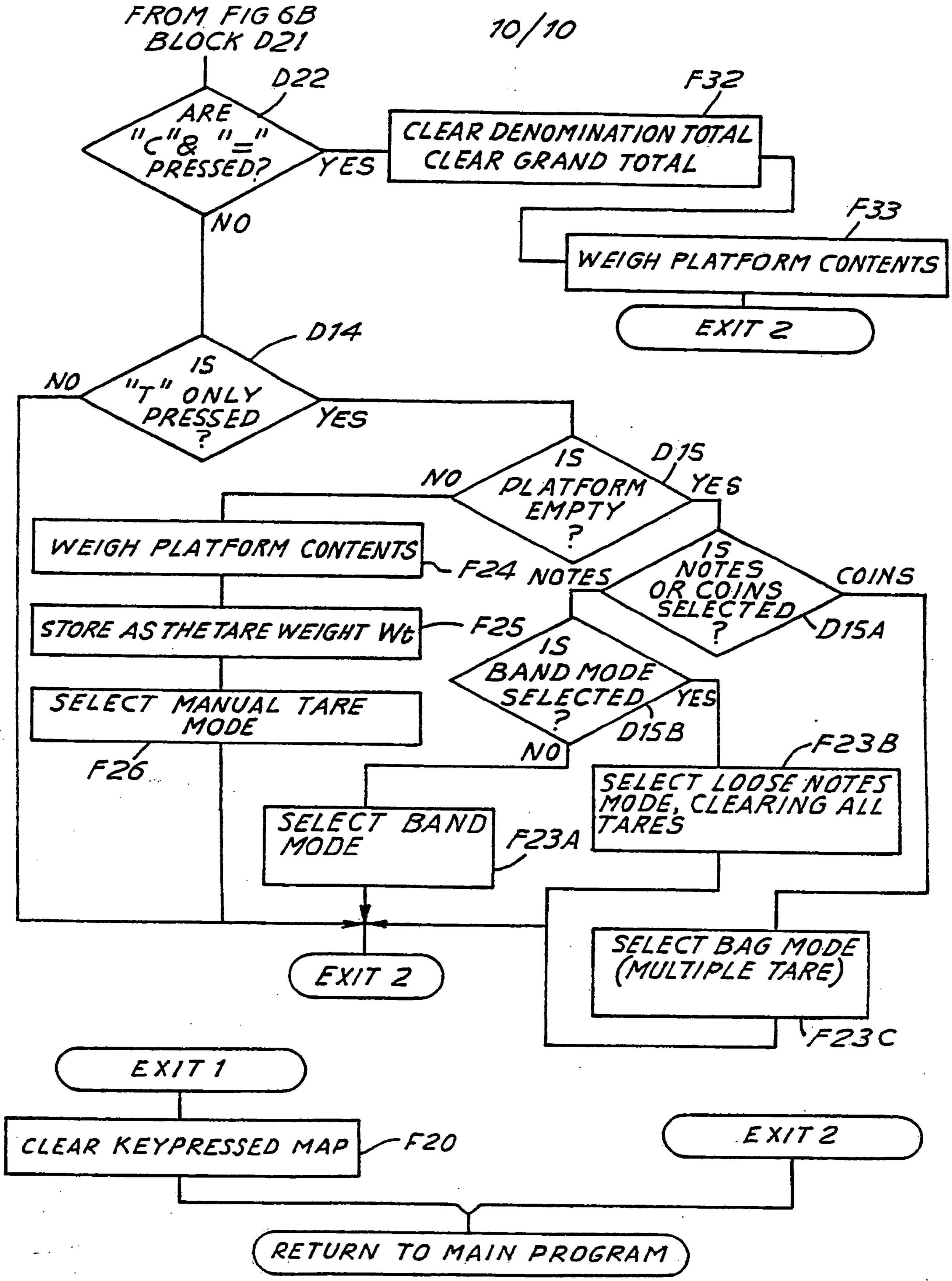

FROM FIG 6B BLOCK D21
D22
ARE "C" & "=" PRESSED?
YES
NO
F32
CLEAR DENOMINATION TOTAL CLEAR GRAND TOTAL
F33
WEIGH PLATFORM CONTENTS
EXIT 2
D14
IS "T" ONLY PRESSED ?
NO
YES
IS PLATFORM EMPTY ?
D15
NO
YES
WEIGH PLATFORM CONTENTS
F24
STORE AS THE TARE WEIGHT Wt
F25
SELECT MANUAL TARE MODE
F26
NOTES
IS NOTES OR COINS SELECTED ?
COINS
D15A
IS BAND MODE SELECTED ?
YES
NO
D15B
F23B
SELECT LOOSE NOTES MODE, CLEARING ALL TARES
SELECT BAND MODE
F23A
SELECT BAG MODE (MULTIPLE TARE)
F23C
EXIT 2
EXIT 1
CLEAR KEYPRESSED MAP
F20
EXIT 2
RETURN TO MAIN PROGRAM

FIG.6C

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 89/00912

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 G01G19/42 ; G01G23/16

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	G01G

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X Y	US,A,4648056 (J.R. WAKEFIELD) 03 March 1987 see column 1, lines 10 - 16 see column 6, lines 34 - 47 see column 7, lines 48 - 59; figure 4	1, 5-7, 15 8-10, 12-14
Y	WO,A,8809485 (PERCELL GROUP LTD) 01 December 1988 see page 2, lines 20 - 22 see page 3, lines 11 - 15 see page 4, lines 5 - 12 see page 4, line 24 - page 5, line 2; figure 2 (cited in the application)	8, 9, 12-14
Y	EP,A,0040539 (PERKAM LTD) 25 November 1981 see page 2, line 26 - page 3, line 22 (cited in the application)	10

° Special categories of cited documents :[10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
23 OCTOBER 1989	06.12.89
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	F.M. VRIJDAG

1

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. PCT/GB 89/00912

SA 30451

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 20/11/89
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A-4648056	03-03-87	CA-A-	1238659	28-06-88
WO-A-8809485	01-12-88	None		
EP-A-0040539	25-11-81	DE-A-	3176893	03-11-88
		GB-A,B	2076979	09-12-81
		US-A-	4447885	08-05-84

EPO FORM P0479

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82